Armed Forces College of Medicine

AFCM

Tubular Processing of the Glomerular Filtrate

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INTENDED LEARNING OBJECTIVES (ILO)

By the end of this lecture the student will be able to:

1. Define reabsorption , secretion and excretion.
2. List mechanisms of tubular transport.
3. Describe Primary active of Na^+.
4. Define Tm of substance.
5. Define renal threshold of a substance.
6. Describe the absoroption by peritubular capillary.

Lecture Plan

1. Part 1 (5 min) Introduction
2. Part 2 (35 min) Main lecture
3. Part 3 (5 min) Summary
4. Lecture Quiz (5 min)

Introduction

- As the glomerular filtrate enters the renal tubule (now called the tubular fluid), it flows through the proximal tubule, the loop of Henle, the distal tubule, the collecting tubule and finally the collecting duct.

- As this tubular fluid passes down the tubules, its volume is reduced and its composition altered by the processes of tubular reabsorption and secretion, to form the urine that enters the renal pelvis.

Introduction

- The rate at which different substances are excreted in urine represents the sum of three processes: glomerular filtration, tubular reabsorption and tubular secretion.

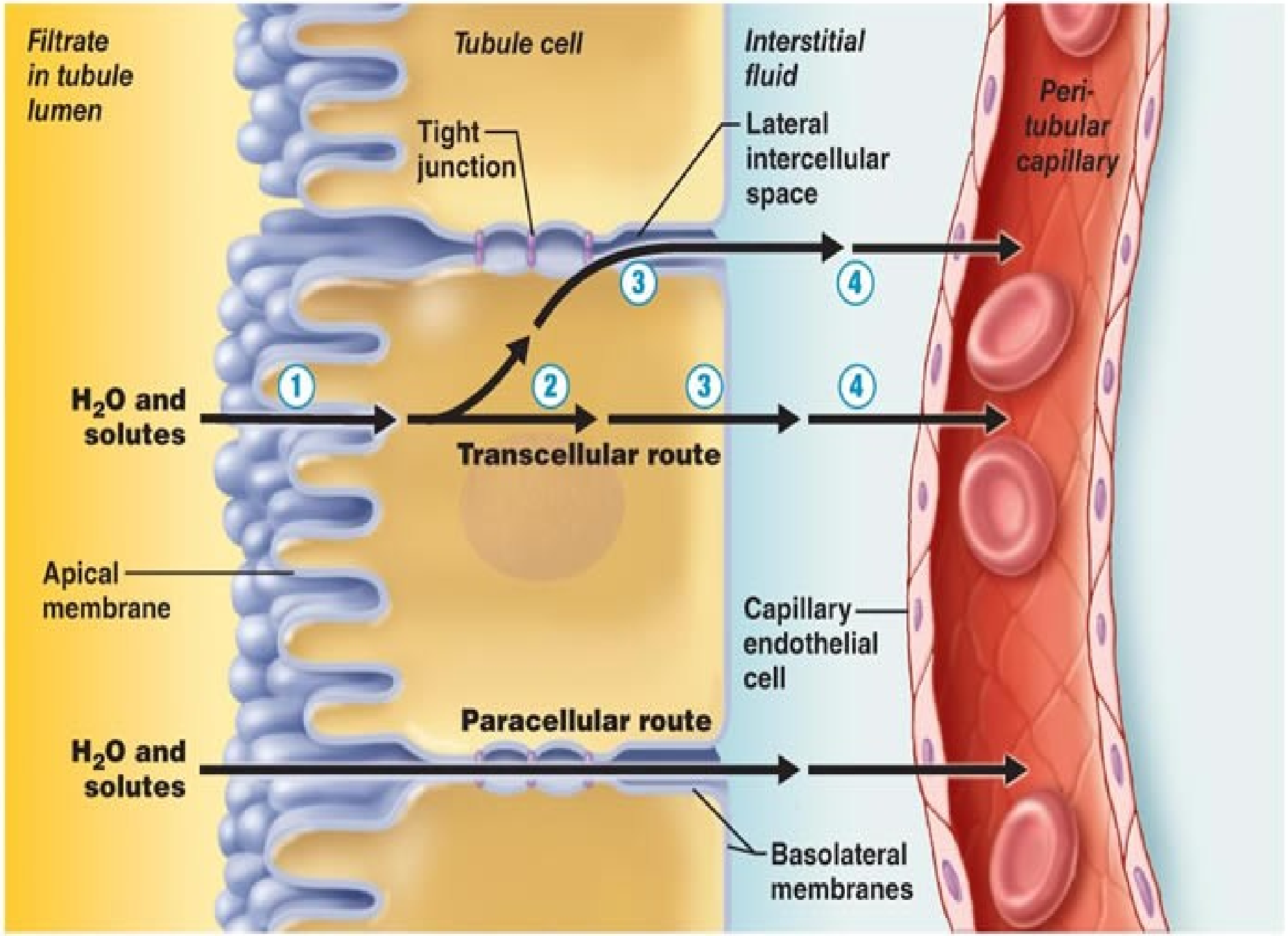
excretion rate = Filtration rate - reabsorption rate + secretion rate.

Tubular Reabsorption

It involves:

1) Transport of the substance across the tubular epithelium into the renal interstitial fluid.

2) Transport from the interstitial fluid into the peritubular capillaries.



The transcellular route involves:

1. Transport across the apical membrane.
2. Diffusion through the cytosol.
3. Transport across the basolateral membrane. (Often involves the lateral intercellular spaces because membrane transporters transport ions into these spaces.)
4. Movement through the interstitial fluid and into the capillary.

The paracellular route involves:

- Movement through leaky tight junctions, particularly in the PCT.
- Movement through the interstitial fluid and into the capillary.

Tubular secretion

Tubular Secretion

Transport of substance from the blood in peritubular capillaries into the renal tubule.

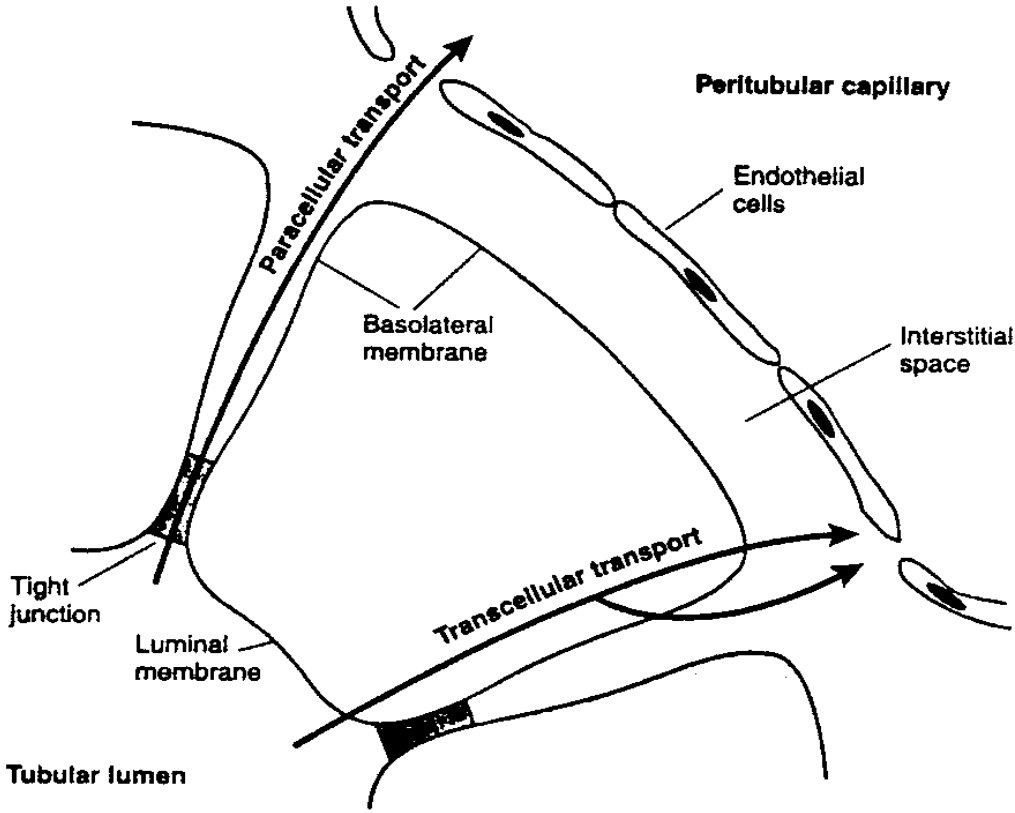
Types of transport across the tubular epithelium

1. Transcellular

Solutes are reabsorbed or secreted through cells.

2. Paracellular

solutes are reabsorbed or secreted through the tight junctions between the cells.



Mechanism of tubular transport

There are three basic principles by which solutes and water are transported across the tubular membrane:

A. Active transport:

❖It's against concentration or electrical gradient.

1. Primary active transport.

2. Secondary active transport.

   a) Co-transport.
   b) Countertransport.

Mechanism of tubular transport

❖Sodium reabsorption across the proximal tubular epithelium is an example of the primary active transport.

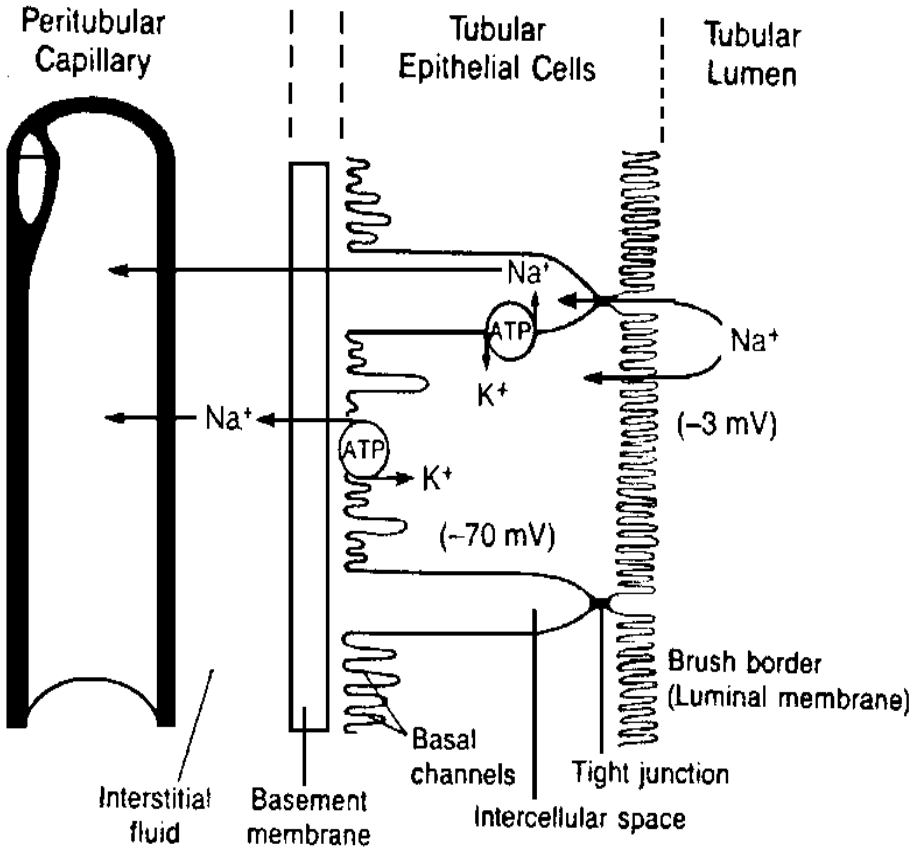
At the basolateral border of the tubular epithelium:

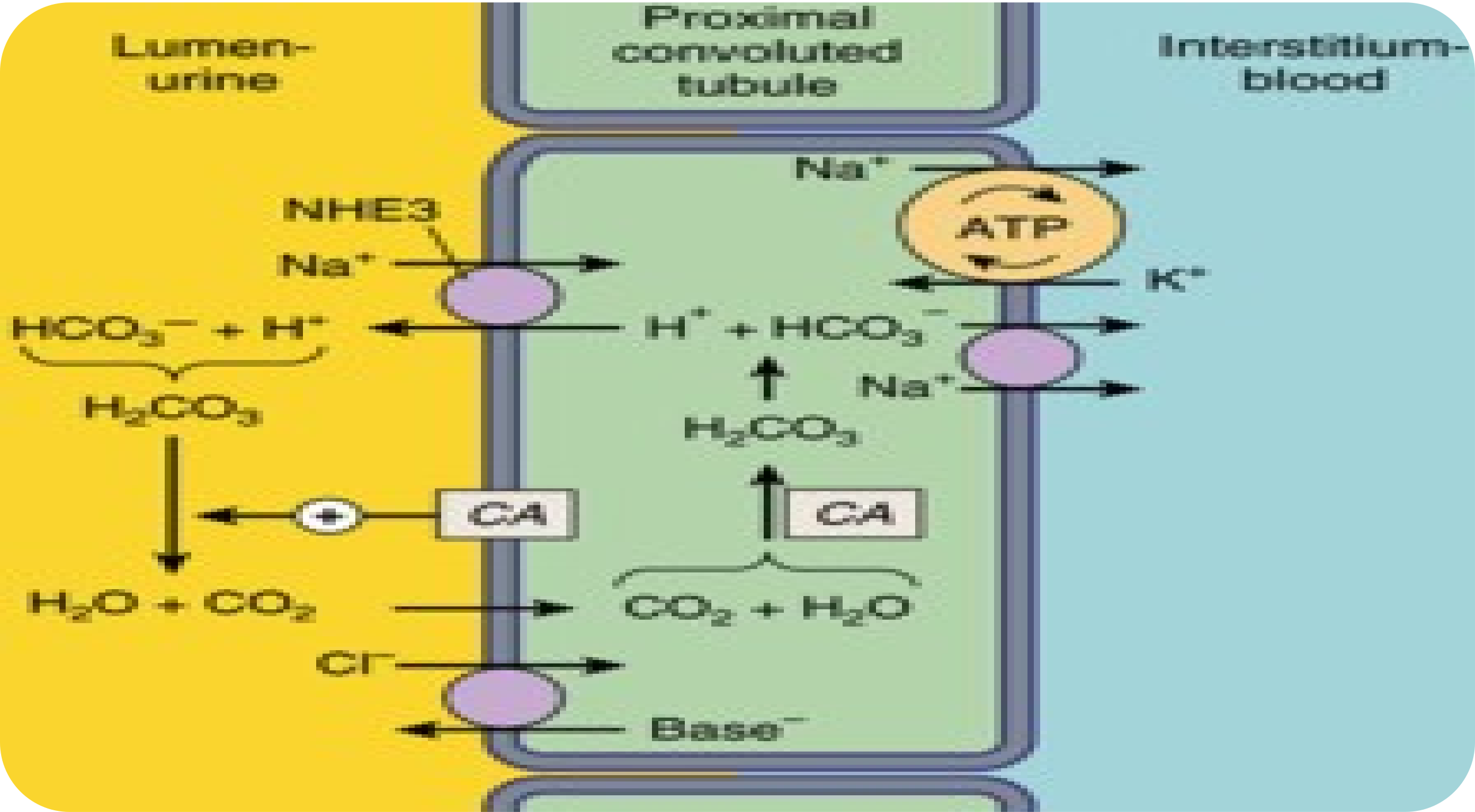
•Na^+ - K^+ ATPase pump extrudes 3 Na^+ into the interstitium in exchange for 2 K^+ that are pumped into the cell. This ion pump results in:-

Mechanism of tubular transport

At the luminal border:

Na^+ diffuses across the luminal membrane from the tubular lumen into the cell due the electrical and chemical gradient.




Lumen-
urine
Proximal
convoluted
tubule
Interstitium-
blood
NHE3
Na+
Na+
ATP
K+
HCO3− + H+
H+ + HCO3−
Na+
H2CO3
H2CO3
CA
CA
H2O + CO2
CO2 + H2O
Cl−
Base−

2. Secondary active transport

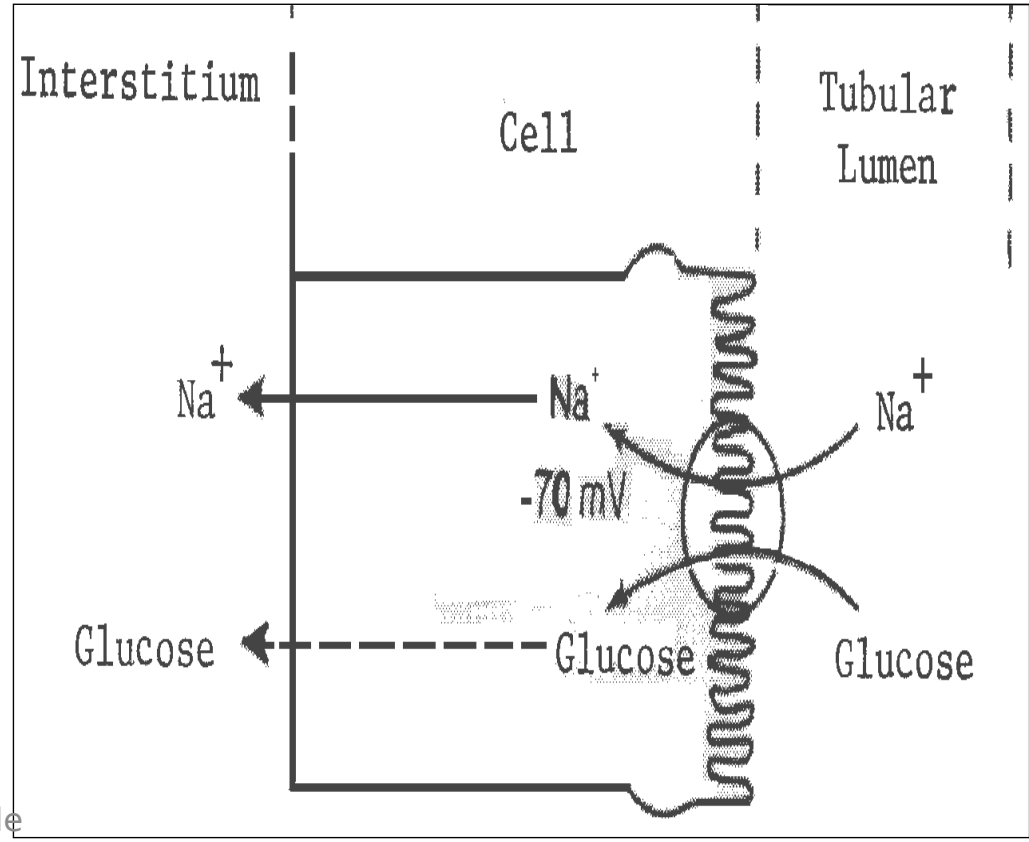
•This type of transport does not require energy directly from ATP or from the high-energy phosphate sources. It is of two types:

a) Co-transport:

•The reabsorption of one substance is linked to passive reabsorption of another substance.

•The direct source of energy is that liberated by simultaneous diffusion of another transported substance down its electrochemical gradient.

•The two substances bind to a specific carrier molecule and are co-transported together across the membrane.



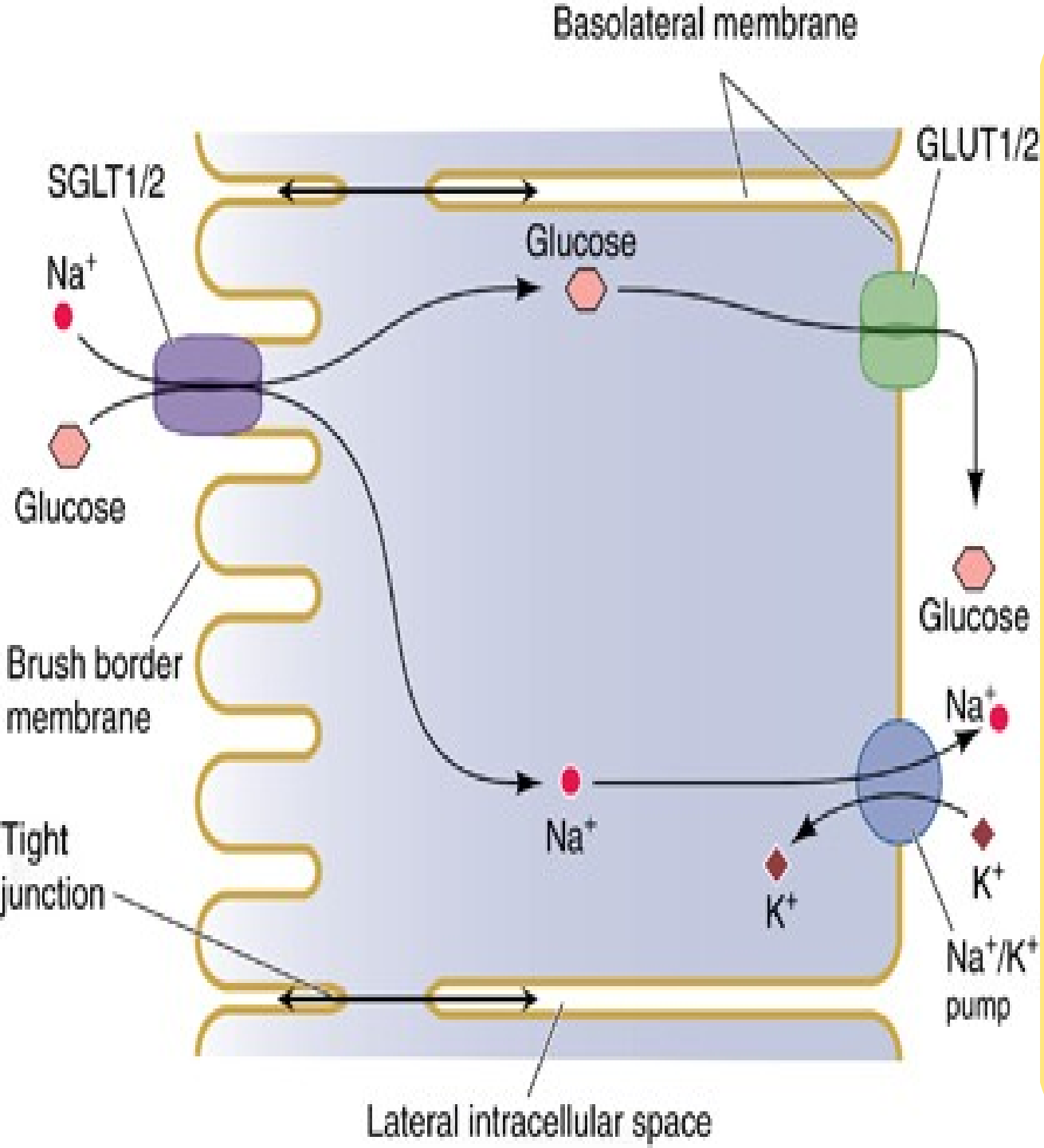
2. Secondary active transport

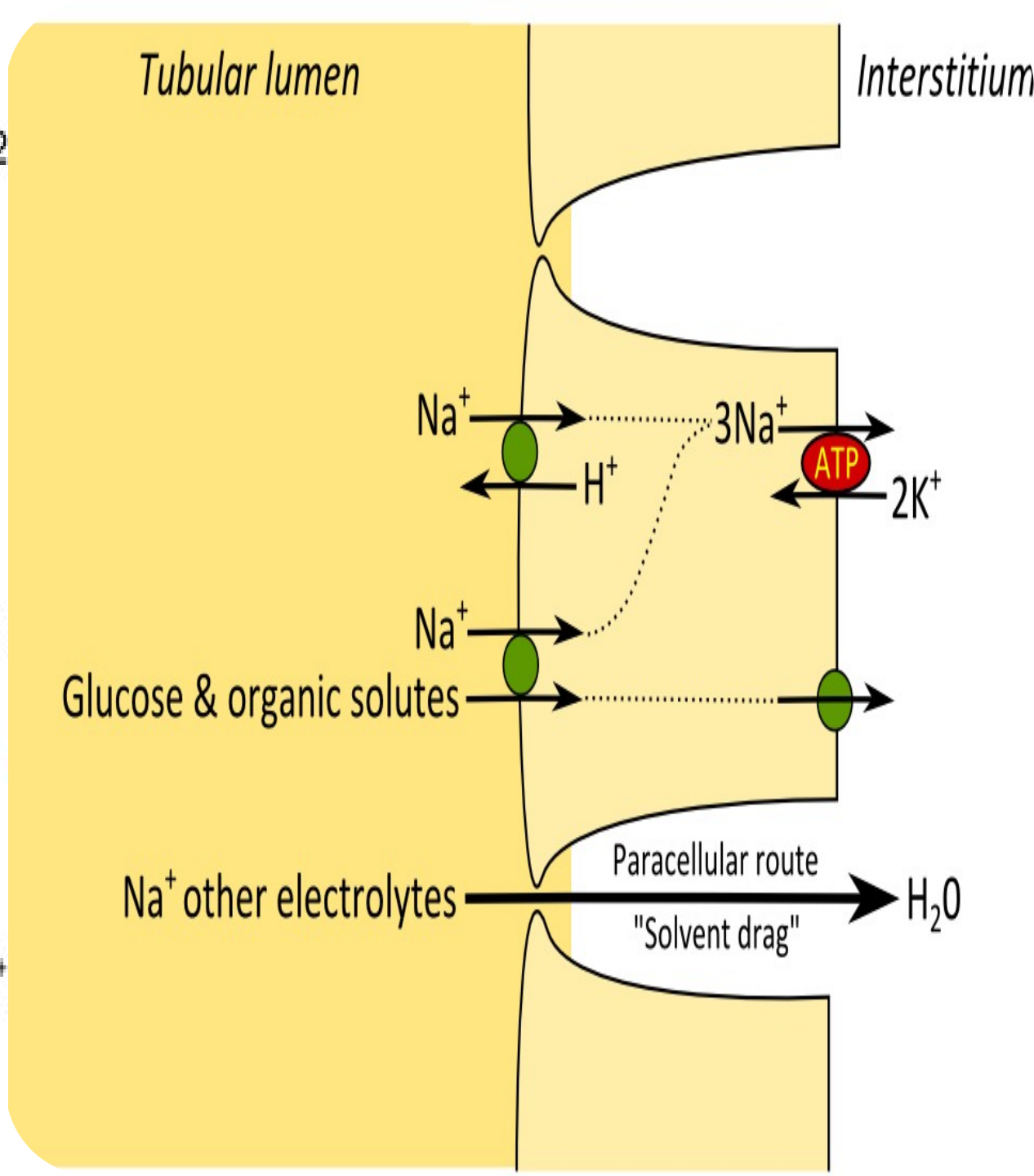
•One of the substances diffuses down its electrochemical gradient while the second substance is transported against its chemical gradient, example: glucose.

- *At the basolateral border:*

-The Na^+ is pumped out of the cell into the lateral intercellular spaces.

- Glucose is transported by another carrier GLUT-2 into the interstitial fluid by facilitated diffusion.


Basolateral membrane
SGLT1/2
GLUT1/2
Glucose
Na+
Glucose
Glucose
Brush border membrane
Na+
Na+
K+
K+
Tight junction
Na+/K+ pump
Lateral intracellular space


Tubular lumen
Interstitium
Na+
3Na+
ATP
H+
2K+
Na+
Glucose & organic solutes
Paracellular route
Na+ other electrolytes
H2O
"Solvent drag"

2. Secondary active transport

b) Countertransport:

- The reabsorption of one substance is linked to secretion of another substance e.g. secondary active secretion of H^+ into the tubule.

- As Na^+ is carried to the interior of the cell, hydrogen ions are forced outward in the opposite direction into the tubular lumen by sodium - hydrogen counter transport protein in the brush border of the luminal membrane, of the proximal convoluted tubule.

B. Passive Reabsorption

1. Passive Reabsorption of Chloride:

2. Osmosis of Water:

- When solutes are reabsorbed out of the tubule, their concentration decreases inside the tubule while increasing in the interstitium.

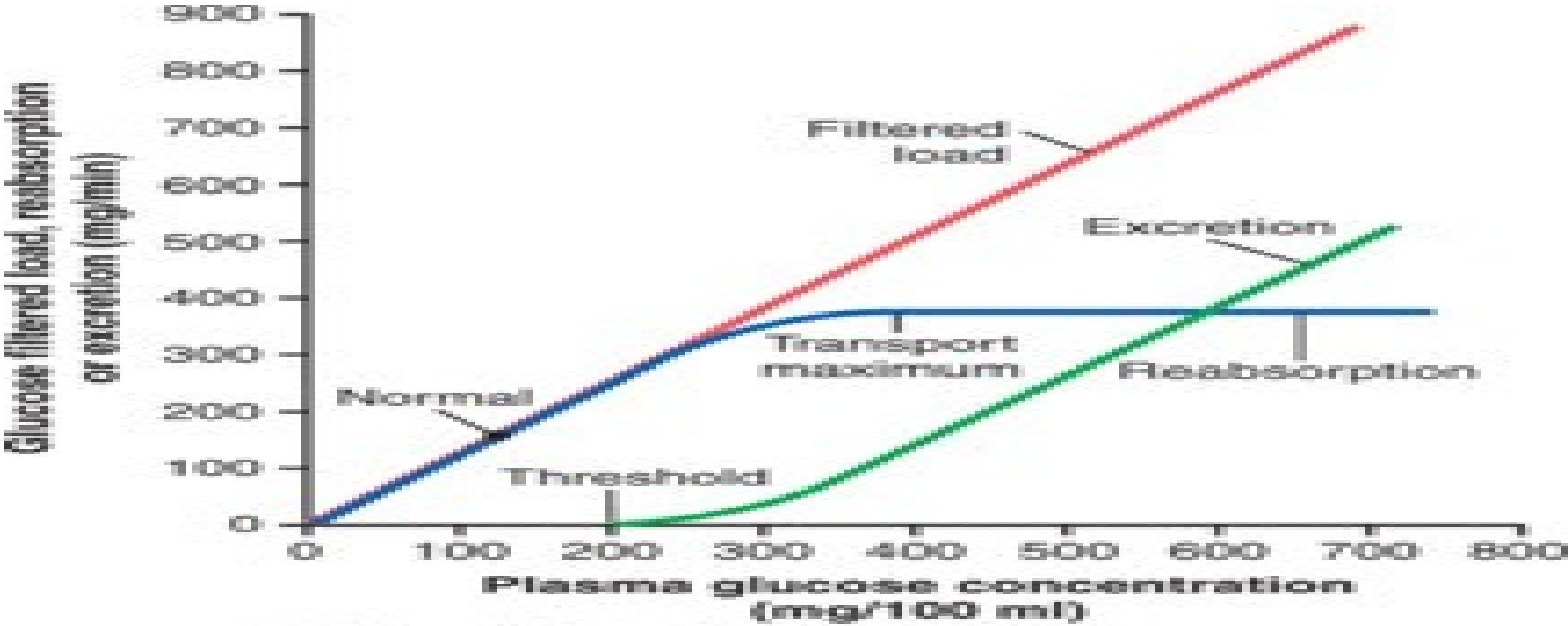
- This creates a concentration gradient that causes osmosis of water.

Passive Reabsorption of Urea .3

- As water is reabsorbed from the tubule, urea concentration in the tubular lumen increases.

- This creates a concentration gradient favouring reabsorption of urea. About 50% of the filtered urea is passively reabsorbed from the tubule and the remainder passes into urine.

Concept of Tubular Maximum and Renal Thresho



Absorption by the peritubular capillaries

• Fluid and electrolytes are reabsorbed from the renal interstitium into the peritubular capillaries by bulk flow.

•The forces that act across the peritubular capillaries are:

1-Forces that favour reabsorption:

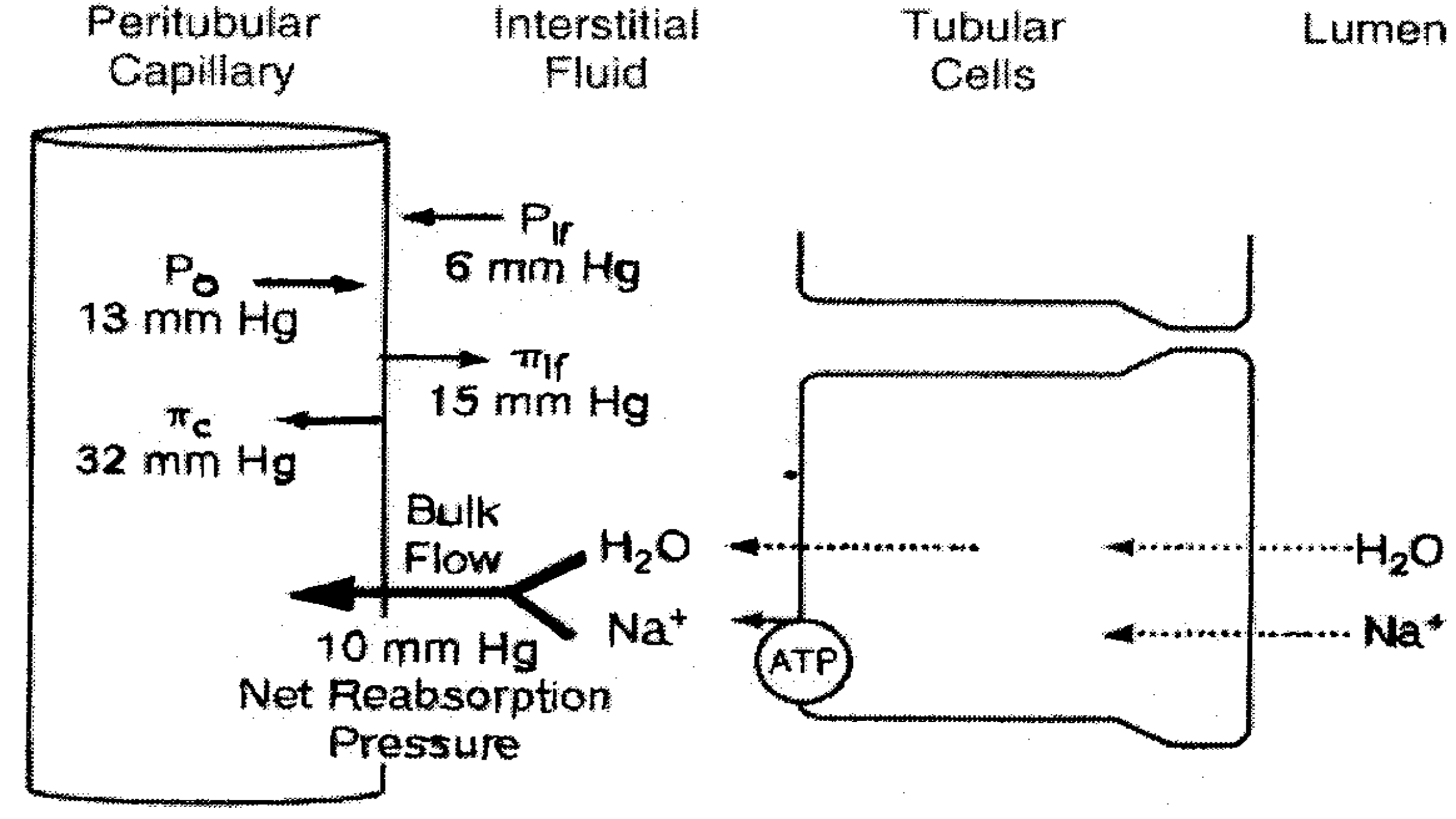
a) The colloidal osmotic pressure of the peritubular capillaries (about 32 mmHg).

b)The hydrostatic pressure in the renal interstitium (about 6mmHg).

2- Forces that oppose reabsorption:

a) The hydrostatic pressure inside the peritubular capillaries (about 13mm Hg).

b)The colloidal osmotic pressure of proteins in the renal interstitium (about 15mm Hg).


Peritubular Capillary
Interstitial Fluid
Tubular Cells
Lumen
P_{If}
6 mm Hg
P_c
13 mm Hg
π_{If}
15 mm Hg
π_c
32 mm Hg
Bulk Flow
H_2O
Na^+
10 mm Hg
Net Reabsorption Pressure
ATP
H_2O
Na^+

Net reabsorptive Force

Net reabsorptive Force = **(32 + 6)** − **(13 + 15)**

= **38 - 28**

= **10 mmHg**

•The uptake of fluid and solutes by the peritubular capillaries is matched to the net reabsorption of water and solutes from the tubular lumen into the interstitium.

Lecture Quiz

Question 1

Transport of gulcose in the renal tubular cells occurs via:

a) active transport.
b) concentration gradient.
c) secondary active transport with sodium.
d) secondary active transport with potassium.

Question 2

Which of the following substances is actively secreted into the renal tubules?

a) Amino acids.
b) Chloride.
c) Glucose.
d) Potassium.
e) Sodium.

SUGGESTED TEXTBOOKS

Textbook of Medical Physiology Eleventh Edition

Guyton and Hall Page 327 - 332.